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Notice of Special Review and Preliminary Determination to Cancel Registration and Deny Applications for Certain Uses of Diazinon Notice of Availability of Support Document

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DIAZINON SUPPORT DOCUMENT

Office of Pesticide Programs
Office of Pesticide Programs and Toxic Substances
U.S. Environmental Protection Agency
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This notice and support document announces EPA's initiation of a Special Review and preliminary determination to cancel registration and deny application for certain uses of the pesticide, Diazinon. The Agency has analyzed the risks and benefits associated with Diazinon use on golf courses and sod farms and has determined that the risks posed by the use of Diazinon satisfy criteria for initiation of a Special Review. It has also been determined that the risks are not outweighed by the benefits of Diazinon use and, therefore, the use of Diazinon on golf courses and sod farms causes unreasonable adverse effects to the environment.

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Executive Summary

This diazinon support document presents the basis for the initiation of a Special Review. It also presents the basis for the issuance of the Preliminary Determination proposing to cancel registrations and deny applications for all pesticide products that contain the active ingredient diazinon and that may be used on golf courses and sod farms. The proposed action is based on the Agency's determination that the use of diazinon on golf courses and sod farms will result in unreasonable adverse effects to non-target birds.

The Agency evaluated acute toxicity studies which indicated that diazinon is very highly toxic to birds. The laboratory toxicity measures which the Agency used to evaluate the acute hazard are the median lethal concentration and the median lethal dose which kill 50 percent of the test organisms (LC_{50} and LD_{50}).

To evaluate this acute hazard, the Agency estimated residue levels on grass and seed to determine if the values would exceed the LC_{50} for grazing and seed-eating birds. The Agency also estimated the dose of diazinon that waterfowl or seed-eating birds would consume from residues on grass and seed to determine if the values would exceed the LD_{50}. Both residue level and dose estimates exceeded the toxicity measures for certain species and thus exceeded the acute avian risk criterion for Special Review. These estimates also support the concern that diazinon will result in adverse effects to birds on golf courses and sod farms.

The bird kills which have been reported to the Agency confirm this hazard. Approximately 60 bird kills have been recorded in which diazinon was either confirmed or implicated as the primary cause. These kills have involved 23 species of birds, including migratory and non-migratory waterfowl, songbirds, shore birds, wading birds, and others. Twenty of these kills have occurred on golf courses and 20 kills on other grassy sites such as lawns, recreational areas, and parks. These incidents have occurred during all months of the year and have been documented throughout the country.

The Agency's concern for acute hazard to avian wildlife include a concern for impact on populations of species at risk. The Agency reviewed information which indicated that diazinon caused a reduction of a local population of Atlantic Brant Geese. On May 7, 1984, Diazinon AG500 was applied according to label directions to a golf course in New York. Approximately 700 Atlantic Brant Geese died. Carcass

analysis revealed acute diazinon poisoning. The New York population of Atlantic Brant was estimated to be 2500 in 1984. The Agency has determined that this loss of 28 percent is a local population reduction and exceeded the Special Review risk criterion for significant local population reduction.

The Agency is also concerned about the effect of diazinon on endangered species. In October 1985, the Agency requested a formal consultation with the Office of Endangered Species, U.S. Department of Interior, and expects a reply by February 1986.

The Agency reviewed information concerning the avian and human hazards of the five major alternatives. Based on estimated residues on grass, the Agency conducted a comparative avian hazard assessment. Although laboratory measures indicate that several of the alternatives are highly acutely toxic to birds, the estimated residues on golf courses and sod farms indicated that the major alternatives are not likely to be of greater hazard to birds than diazinon. However, as additional information is received and reviewed on the alternatives, the Agency will determine whether or not to take regulatory action on any of the alternatives.

The Agency has also reviewed information concerning the human toxicity of diazinon and its alternatives. This includes data on the oncogenicity, mutagenicity, reproductive effects, and teratogenicity/fetotoxicity for many of the alternatives. Based on the available data, the alternatives do not appear to pose a greater human health hazard than diazinon.

The Agency is proposing to cancel the use of diazinon on golf courses and sod farms. The benefits of diazinon on these sites were assessed in terms of the economic impacts which would result if diazinon was cancelled and users forced to use substitute alternatives. Agency estimates indicate that at least 512,000 pounds are used per year on golf courses and 60,000 pounds on sod farms. The impact of cancellation would be a cost increase of $300,000 for sod farms and $937,200 for golf courses. The Agency anticipates that these cost increases would not cause a severe impact when compared to the gross revenue of $210,000,000 on sod farms and the maintenance cost of $1,900,000,000 for golf courses or impact of $0.07 per golfer.

In weighing risks and benefits, the Agency reviewed a number of options other than cancellation to reduce the risk to birds. Among these measures were (1) additional precautionary labeling concerning the hazard to birds, (2) restricting diazinon application to certain months of the year,

(3) restricting application geographically, and (4) reducing the application rate. The Agency evaluated these measures and determined that they would not adequately mitigate the risk.

As a result the Agency is proposing cancellation of diazinon on golf courses and sod farms. The decision to cancel diazinon on these sites is based on the conclusion that the risk to birds outweighs the benefits of use.

The Agency wants to emphasize that the concern about the risk of diazinon to birds is not limited to golf courses and sod farms. The Agency does not have sufficient data to evaluate all of the sites for which diazinon is registered, but will require such data under FIFRA 3(c)(2)(B). Pending the review of these data, the Agency may or may not initiate a Special Review on any or all of these other sites.

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I. INTRODUCTION

A. General Background and Organization

The Environmental Protection Agency (EPA) is initiating a Special Review of all pesticide products that contain the active ingredient diazinon and that may be used on golf courses and sod farms. This diazinon support document presents the basis for the initiation of the Special Review and proposes regulatory action to reduce the potential adverse effects from diazinon's use on these two sites. The Agency evaluated the risks to birds from diazinon based on (1) acute avian toxicity, (2) estimated residues on grass and seed, (3) bird kills, and (4) a local population reduction of Atlantic Brant Geese. The benefits associated with the use of diazinon on these sites were also evaluated. EPA has concluded that there are substantial risks to birds associated with the use of diazinon on these sites and proposes a regulatory decision in this document.

This support document contains four parts. Chapter I is this Introduction. Chapter II describes the risk to birds resulting from diazinon application to golf courses and sod farms. This chapter includes descriptions and evaluations of the risk information and the Agency's conclusions. Chapter III contains a discussion and quantitative estimate of the benefits of diazinon use on golf courses and sod farms and describes the assumptions and limits of these estimates. Chapter IV describes the possible regulatory options to reduce the risk of diazinon, evaluates the risks and benefits of these regulatory options, and summarizes the regulatory action which the Agency proposes to take.

B. Legal Background

1. The Statute

A pesticide product may be sold or distributed in the United States only if it is registered or exempt from registration under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) as amended (7 U.S.C. 136 et seq.). Before a product can be registered, it must be shown that it can be used without "unreasonable adverse effects on the environment" (FIFRA section 3(c)(5), that is, without causing "any unreasonable risk to man or the environment, taking into account the economic, social, and environmental costs and benefits of the use of the pesticide" (FIFRA section 2(bb)). The burden of proving that a pesticide meets this standard for registration is at all times on the proponent of initial or continued registration. If at any time the Agency determines that a pesticide no longer meets this standard for registration, then the Administrator may cancel the registration under section 6 of FIFRA.

2. The Special Review Process

The term "Special Review" is the name being used for the process previously called the Rebuttable Presumption Against Registration (RPAR) process (40 CFR 162.11). Modifications to the process are described in the final Special Review regulations (50 FR 49003). These regulations will become effective after 60 days of continuous congressional session after the promulgation of the regulations, which took place on November 19, 1985. These modifications include new risk criteria. Until these regulations are adopted, the present RPAR procedures will remain in effect as set forth in 40 CFR 162.11.

The Special Review process provides a mechanism through which the Agency gathers risk and benefit information about pesticides, which appear to pose risks of adverse effects to human health or the environment that may be unreasonable. Through issuance of various Notices and support documents, the Agency publicly sets forth its position and invites pesticide registrants, U.S. Department of Interior, Food and Drug Administration, U.S. Department of Agriculture, user groups, environmental groups, and other interested persons to participate in the Agency's review of suspect pesticides.

Risk evidence submitted to and/or gathered by the Agency must be evaluated and considered in light of the benefit information. If the Agency determines that the risks appear to outweigh the benefits, the Agency can initiate action under FIFRA to cancel, suspend, and/or require modification of the terms and conditions or regulation.

C. Chemical Background

1. Chemical and Physical Characteristics

Diazinon is the common name for O,O-diethyl O-(2-isopropyl-6methyl-4-pyrimidinyl) phosphorothioate. Trade names include but are not limited to the following: Spectracide, AG500, Sarolex, D-Z-N Diazinon 14G, and Spectracide Lawn and Garden Insect Control.

Physically, diazinon in its pure form is a colorless liquid, with the technical being amber to brown in color. The boiling point of pure diazinon is 83 °C to 84 °C.

2. Registered Uses and Production

Agency records show registrations for over 500 federally registered pesticide products that contain diazinon as an active ingredient and that may be used on the general category of ornamental lawns and turf. These registrations are

held by over 200 registrants. Ciba-Geigy Corporation is the major producer of the technical material.

The types of formulations used on golf courses and sod farms are the wettable powder and emulsifiable concentrate, which are applied as a liquid formulation and the granular formulation.

According to Agency records at least 8,000,000 pounds are used per year. Approximately 512,000 pounds are used on golf courses and 60,000 pounds on sod farms.

II. ASSESSMENT OF RISK

EPA has concluded that the risks resulting from the use of diazinon on golf courses and sod farms exceed the existing criteria (40 CFR 162.11) and new risk criteria (50 FR 49003) for hazard to birds. EPA has also concluded that the use of diazinon on golf courses and sod farms may result in unreasonable adverse effects to birds. Section A of this chapter discusses the Agency's risk assessment regarding acute toxicity to birds. To evaluate the acute hazard the Agency estimated exposure to diazinon residues to determine if the measures of acute toxicity were exceeded. Exposure estimates did indeed exceed measures of acute toxicity for certain bird species. The Agency also considered information concerning bird kills involving migratory and nonmigratory waterfowl and other birds. The bird kills on golf courses and other grassy sites occurred during all months of the year except February and throughout the United States. The Agency is also concerned about the hazard of direct ingestion of diazinon granules. In addition field studies, which were not valid according to Agency guidelines, were also considered. Limited conclusions concerning cholinesterase inhibition and body weight loss could be drawn and supported the Agency's concern about diazinon's toxicity. Section B details a significant local population reduction of Atlantic Brant Geese caused by diazinon. Seven hundred Atlantic Brant Geese or 28 percent of the local population died as a result of acute diazinon poisoning after a golf course was treated following label directions.

The Agency became concerned because of bird kills associated with diazinon application. (See Section II.A.2.g.) Most of these bird kills are associated with large grassy sites. As a result the Agency has targeted golf courses and sod farms for this Special Review.

The Agency is concerned about the effect of diazinon application to birds on other sites as well. Bird fatalities on home lawns and in agricultural sites have also been reported. Bird poisonings in general go unnoticed and unreported, especially when they occur on home lawns and agricultural crops because such incidents are less conspicuous. A group of dead birds such as waterfowl are more noticeable on large grassy areas such as golf courses than in a cornfield, for example. Birds may go into brush or cover when dying and go unnoticed, or a farmer or a homeowner may not attribute the deaths of a few birds to recent insecticide application. As a result the Agency suspects that the number of incidents may be greater than the number of reports indicates. However, the data base is inadequate to evaluate the hazard on all sites at this time. The Agency will require the data necessary to fully evaluate the hazard under FIFRA section 3(c)(2)(B). Once the Agency has reviewed these data, the Agency will determine whether or not to take regulatory action, including whether or not to initiate a Special Review on any or all of these other sites.

The Agency is also concerned about the protection of endangered species found on diazinon-treated golf courses and sod farms. As a result of that concern, in October 1985, the Agency requested a formal consultation with the Office of Endangered Species, U.S. Fish and Wildlife Service, U.S. Department of the Interior (as required by section 7 of the Endangered Species Act of 1973, as amended). A reply is expected by February 1986.

A. Acute Toxicity of Diazinon

1. Introduction

EPA has determined that the use of diazinon on golf courses and sod farms exceeds the existing risk criterion for acute avian toxicity in 40 CFR 162.11(a)(3)(i)(B)(2), which provides that a Special Review shall be conducted if a pesticide "occurs as a residue immediately following application in or on avian feed of an avian species, representative of the species likely to be exposed to such feed in amounts equivalent to the average daily intake of such representative species, at levels equal to or greater than the subacute dietary LC_{50} measured in avian test animals as specified in the Registration Guidelines." These diazinon products also meet or exceed the new risk criterion (50 FR 49003) because residue concentrations may result "in residues of the pesticide product or its ingredients, impurities, metabolites or other degradation products in the environment of nontarget organisms at levels which equal or exceed concentrations acutely or chronically toxic to such organisms . . . ."

The Agency has also concluded that diazinon application to golf courses and sod farms may result in unreasonable adverse effects to birds. In this chapter, the Agency reviews information concerning diazinon's acute avian toxicity and presents its hazard evaluation, which is the basis for this conclusion.

2. Hazard Evaluation

This section describes the Agency's evaluation of the avian hazard resulting from diazinon application to golf courses and sod farms. In this evaluation the Agency considered (1) exposure, (2) acute toxicity, (3) estimated residues on grass and seed, (4) estimated dose levels consumed by birds, (5) specific problems associated with the granular formulation, (6) field studies, and (7) bird kills. The hazard was evaluated for grazing birds such as Mallard Ducks and other waterfowl, which are frequently found feeding on open grassy sites. The hazard was also evaluated for seed-eating birds such as quail, pheasant, and certain songbirds. Seed-eating birds are also known to forage on grassy sites (Peterson, 1980; National Geographic Society, 1983), and certain omnivorous birds such as Red-winged Blackbirds may feed on seeds as they search for insects. Although seeds may not occur as frequently on golf courses and commercial sod farms as in a more natural setting, birds may still forage on these sites for seeds or insects.

a. Exposure to Diazinon

Dietary exposure to diazinon on golf courses and sod farms occurs when birds feed on grass, roots, seed, and/or the invertebrates associated with the grass. Birds may also ingest diazinon granules accidentally while feeding. Dermal exposure to diazinon residues on the grass may also occur as they feed.

Exposure to high concentrations of diazinon may also occur. Rain or irrigation (watering in) after diazinon application may result in the formation of pools of contaminated water (puddling), which poses an additional hazard to birds. Irrigation is recommended by the label for control of certain pests on grass. If the water is not immediately absorbed by the soil, puddles with high concentrations of diazinon may form. Exposure to high concentrations of diazinon from drinking the contaminated water or feeding in the puddles may occur.

In cases of too little, ineffective, or no irrigation, granules and residues remain on the grass surface and are not moved into the thatch and soil. Hot spots of diazinon concentration may result and exposure to high concentrations of diazinon may occur under these circumstances as well.

Bird kills from diazinon application have been associated with irrigation and puddling, which may occur even when label directions are followed. The Agency is concerned that even if applicators comply with label directions, diazinon may still be hazardous because of the practical difficulties in achieving proper irrigation. For example case numbers 6, 11, 34, and 42 in Stone and Gradoni's report (1985) are waterfowl kills associated with improper irrigation, puddling, and/or run-off problems. Faatz (1985a and 1985b) also reported a waterfowl kill which was associated with irrigation problems.

b. Acute Toxicity Measures

To evaluate the acute toxicity of diazinon, the Agency has reviewed several acute toxicity studies (Hill et al., 1975; Schafer and Brunton, 1979; Balcomb et al., 1984; Hill and Camardese, 1984; Hudson et al., 1984). These studies used the median lethal concentration and the median lethal dose, which kill 50 percent of the test organisms (LC_{50} and LD_{50}), to evaluate diazinon's acute toxicity. The results of these studies characterize diazinon as very highly toxic to birds. The Agency has determined that these studies meet Agency guidelines for proper conduct of studies. The results of these studies are summarized in parts per million (ppm) and milligrams per kilogram (mg/kg) in the following tables. The results are based the technical formulation.

Avian Subacute Dietary LC_{50} (ppm)

191 for Mallard Ducks
245 for Bobwhite Quail
244 for Ring-necked Pheasant
47 for Japanese Quail

Avian Acute Oral LD_{50} (mg/kg)

3.5 for Mallard Ducks
10.0 for Bobwhite Quail
4.3 for Ring-necked Pheasant
7.5 for House Sparrows
3.2 for Red-winged Blackbirds

c. Estimated Residue Levels of Diazinon on Grass and Seeds

The Agency estimated residue levels on golf courses and sod farms (U.S. EPA, 1985e). Residue levels were estimated for grass to compare with the LC_{50} for grazing birds. Estimates were also made for seeds to compare to the LC_{50} for seed-eating birds.

Estimates of residues on grass and seeds were made for the wettable powder and emulsifiable concentrate which are applied as a liquid (L) formulation and the granular (G) formulation. Estimates were made for residue levels immediately following application and six weeks later. Estimated residues are expressed as average and maximum residues.

For the L formulations, residues were estimated based on three application rates. The first was 11 pounds active ingredient per acre (lb ai/A). This is the maximum allowable rate and may be used only for millipedes, which are a very minor turf pest. The second was 8 lb ai/A. This was the maximum allowable rate for chinch bugs, a major turf pest. The third is 3 lb ai/A. This is the lowest application rate and may be used only for the major turf pests--sod webworms, bill bugs, and mole crickets.

For the G formulation, two application rates were used. The first was the maximum label rate of 6 lb ai/A, the rate for billbugs and white grubs. The second rate was 3 lb ai/A, the lowest label rate and is targeted against chinch bugs.

Because of the lack of residue data for diazinon, the Agency based its estimates of diazinon residues and their decline over six weeks on ratios reported by Kenaga (1973). Kenaga used the following assumptions:

- Pesticides behave similarly in dispersing to and settling upon surface areas following application.

- The highest residues occur on treated food with the highest surface area-to-mass ratios and the greatest exposure to the pesticide application.

The ratios were based on quantified residue studies of 21 representative pesticides, including diazinon, used in or on 36 different crops (Kenaga, 1973). The ratios are expressed as residue (ppm) per pound of pesticide per acre.

Kenaga (1973) gives the following values in ppm for short and long grass and seeds to be used in a ratio with 1 lb pesticide/A:

Pesticide Residues (ppm)

	Immediately After Application		6 Weeks Later	
	Average	Maximum	Average	Maximum
Short Grass	125	240	5	30
Long Grass	92	110	5	20
Seeds	3	12	0.1	1.5

The Agency used multiples of these ratios to estimate residue levels for different application rates.

The results of Agency calculations of residues on grass (ppm) were as follows:

Diazinon Residues (ppm) on Grass

Application Rate	Short Grass Average	Short Grass Maximum	Long Grass Average	Long Grass Maximum
11 lb ai/A (L)				
- immediately following	1375	2640	1012	1210
- 6 weeks later	55	330	55	220
8 lb ai/A (L)				
- immediately following	1000	1920	736	880
- 6 weeks later	40	240	40	160
6 lb ai/A (G)				
- immediately following	750	1440	552	660
- 6 weeks later	30	180	30	120
3 lb ai/A (L and G)				
- immediately following	375	720	276	330
- 6 weeks later	15	90	15	60

All of the average and maximum estimated residues immediately following application for all four application rates greatly exceeded the Mallard Duck LC_{50} of 191 ppm.

The results for residues on seeds were as follows:

Pesticide Residues (ppm) on Seeds

Application Rate	Average	Maximum
11 lb ai/A (L)		
- immediately following	33	132
- 6 weeks later	1.1	16.5
8 lb ai/A (L)		
- immediately following	24	96
- 6 weeks later	0.8	12
6 lb ai/A (G)		
- immediately following	18	72
- 6 weeks later	0.6	9
3 lb ai/A (G and L)		
- immediately following	9	36
- 6 weeks later	0.3	4.5

The LC_{50} of 245 ppm for Bobwhite Quail was not exceeded. However, the maximum estimated diazinon residues on seeds immediately following application of 6, 8, and 11 lb ai/A are approximately twice the LC_{50} of 47 ppm for the closely related species, the Japanese Quail.

d. Estimated Dose of Diazinon Consumed by Birds

To evaluate the hazard to birds from eating diazinon residues on grass and seed, the Agency estimated the dose of pesticide a bird would consume (U.S. EPA, 1985e) based on (1) the estimated residue levels presented above, (2) estimated average daily food consumption, and (3) body weight. The results were compared to the LD_{50} for grazing waterfowl and seed-eating birds to determine if they were exceeded. The following assumptions were made:

- A grazing waterfowl weighs 1000 grams (g) and a seed-eating bird weighs 170 g (Dunning, 1984).
- A grazing waterfowl eats 6.7 percent and a seed-eating bird 8.8 percent of their body weight on an average daily basis (Kenaga, 1973).

These percentages reflect dry weight of food with less than 15 percent moisture content. To adjust for the wet food upon which waterfowl feed, the Agency used a standard conversion of one unit dry weight equals three units of wet weight (Stickel et al., 1965). Because dry weight reflects the normal diet of a seed-eating bird, no adjustment was made. The estimates for the weight of the average daily food consumption of a 1000 g waterfowl are 201 g/day and for a 170 g seed-eating bird, 15 g/day. These estimates are summarized in table II-1.

These estimated average daily intake values for diazinon residues on bird food may be compared to the laboratory LD_{50} of 3.5 mg/kg for Mallard Ducks and 10 mg/kg for Bobwhite Quail. With the exception of the low application rate six weeks after application, estimates for grazing birds exceed the Mallard Duck LD_{50}. The estimates for a seed-eating bird do not exceed the LD_{50} for seed-eating birds. However, the ingestion of diazinon granules may be a greater hazard to seed-eating birds than ingestion of diazinon residues on seeds. (See section II.A.2.e.)

These results, which are based on average daily consumption, may underestimate the risk because a twofold to threefold difference in the daily rate of consumption can occur (Kenaga, 1973; Bellrose, 1976). For example, some waterfowl gorge themselves in the winter and spring just before migration. Also, birds eating food such as grass, which has a high moisture content, may need to consume more food than birds with diets low in moisture content. Increased bulk is needed for equivalent nutritive value. Thus, the exposure to grazing birds, especially waterfowl, may often be higher than indicated by estimates based on average daily consumption.

e. Additional Information Concerning Granular Formulations

The foregoing hazard assessment, which was based on laboratory toxicity tests using technical diazinon, portrays the risk to birds from most diazinon formulations. However, the Agency has special concerns particular to the G formulation. Birds may accidentally ingest the diazinon granules because the granules may be mistaken for dietary grit. Balcomb (1979) reported that birds pick up synthetic grit of mesh size 10, crushed limestone of mesh size 16 to 100, and dicalcium phosphate of mesh size 12 to 40. Diazinon granules have a mesh size of 30 to 40, which is within the size range of dietary grit for birds. The assessment using the technical formulation of diazinon considers only exposure from residues on grass and

Table II-1. Estimated Dose (mg/kg) of Diazinon Consumed by Grazing Waterfowl and Seed-Eating Birds Based on Body Weight, Residues on Grass, and Average Daily Food Consumption

	Dose (mg/kg) Consumed by Grazing Waterfowl			
	Residues* on Short Grass		Residues on Long Grass	
Application Rate	Average	Maximum	Average	Maximum
11 lb ai/A (L)				
- immediately following	276	530	203	243
- 6 weeks later	11	66	11	44
8 lb ai/A (L)				
- immediately following	201	386	148	177
- 6 weeks later	8	48	8	32
6 lb ai/A (G)				
- immediately following	150	290	110	132
- 6 weeks later	6	36	6	24
3 lb ai/A (L and G)				
- immediately following	75	145	55	66
- 6 weeks later	3	18	3	12

	Dose (mg/kg) Consumed by Seed-eating Birds	
	Residues on Seed	
	Average	Maximum
11 lb ai/A (L)		
- immediately following	0.5	2
- 6 weeks later	0.02	0.2
8 lb ai/A (L)		
- immediately following	0.4	1
- 6 weeks later	0.2	0.2
6 lb ai/A (G)		
- immediately following	0.3	0.8
- 6 weeks later	0.15	0.15
3 lb ai/A (L and G)		
- immediately following	0.1	0.7
- 6 weeks later	0.007	0.07

* Residues based on Kenaga, 1973.

seeds. This assessment may underestimate the risk from the G formulation because it does not consider the direct ingestion of granules. To evaluate the hazard the Agency estimated the LD_{50} for direct ingestion of individual granules (U.S. EPA, 1985e).

Information in the open literature verifies the concern over the G formulation. Balcomb et al. (1984) investigated the toxicity of G insecticides to wild-caught songbirds. In testing diazinon 40 percent mortality occurred in test groups of House Sparrows when dosed with a single granule of the 14 percent ai G formulation. In the same study 100 percent mortality occurred in House Sparrows and Red-winged Blackbirds dosed with 5 granules of the diazinon 14 percent ai formulation.

Balcomb et al. (1984) and Hill and Camardese (1984) conducted studies to determine LD_{50} values from G pesticides, including diazinon. Granular diazinon was placed in a gelatin capsule and administered orally to the birds. The results are as follows:

Avian Acute Oral LD_{50} (mg/kg)

8.0 for Bobwhite Quail
1.8 for Red-winged Blackbirds
2.5 for House Sparrows

Based on these LD_{50} values, the LD_{50} may be recalculated in terms of individual granules to reflect the hazard of direct granular ingestion. The Mallard Duck was not tested in the studies using encapsulated granules and so the technical LD_{50} was used (Hudson et al., 1984).

The Agency used the following assumptions:

- Diazinon 14 percent ai granules weigh 0.3 mg each (Balcomb et al., 1984).
- Each granule contains 0.04 mg ai, which is based on the average granule weight and diazinon concentration of 14.3 percent ai.
- A Mallard Duck weighs 1.2 kg; a Bobwhite Quail 0.170 kg; a Red-winged Blackbird 0.042 kg; and a House Sparrow 0.025 kg (Dunning, 1984).

The following calculations were made to estimate the LD_{50} values for individual granular ingestion:

- LD_{50} (mg/kg) X body weight (kg) = mg ai/animal.
- Granular weight (mg) X percent ai = mg ai/granule.
- (mg ai/animal) / (mg ai/granule) = Number of granules that are equivalent to LD_{50}.

The results are:

Number of Granules Equivalent to Avian Acute Oral LD_{50}

105 granules for Mallard Ducks
34 granules for Bobwhite Quail
2 granules for Red-winged Blackbirds
2 granules for House Sparrows

These results indicate a hazard for birds, especially small ones. The Agency estimates that approximately 208 granules per square foot are applied using the 14 percent ai G formulation at the 6 lb ai/A application rate. Because this exceeds the number of granules that are equivalent to the LD_{50}, hazardous exposure for these birds exists within a single square foot of turf.

f. Field Studies

Ciba-Geigy Corporation submitted two field studies concerning diazinon use on turf and the resulting avian hazards (Ciba-Geigy Corporation, 1983a and 1983b). The first was a residue and field dissipation study conducted on plots of turf. The second was a waterfowl study which used Mallard Ducks and Canada Geese penned on turf treated with diazinon. Both studies used the G and emulsifiable concentrate formulations. Diazinon was applied with and without irrigation, except that Canada Geese in the waterfowl study were not tested with irrigation following application.

The Agency reviewed both studies and determined that neither meets Agency standards for the proper conduct of studies (U.S. EPA, 1984a; U.S. EPA, 1984b). Several problems were common to both studies. The plots were too small to (1) adequately simulate distribution of residues on large areas such as golf courses where concentration of diazinon might be expected, (2) simulate normal or worst-case application and irrigation procedures, and (3) simulate the environmental conditions of waterfowl exposed to turf treated with diazinon. In addition, there were problems particular to the individual studies. The waterfowl study did not test Canada Geese on irrigated plots of either formulation, and the Mallard Ducks, which were tested on both the irrigated and nonirrigated plots of both formulations, were not penned on the irrigated plots until the day following application. The residue study did not result in firm conclusions. Trends concerning the movement and dissipation of diazinon residues could not be established or correlated with rainfall, irrigation, application rate, or formulation. Diazinon residues randomly increased or decreased throughout the study.

Although these studies were not valid according to EPA's guidelines, limited conclusions can be drawn from these studies. Mallard Ducks, penned on turf treated with less than maximum label rates, suffered a significantly greater rate of body weight loss and significant brain acetyl-cholinesterase depression relative to control Mallards. These effects are important because the birds may die directly from these effects or because they are rendered more vulnerable to other sources of mortality such as predation. Canada Geese, when similarly exposed to turf treated with less than maximum label rates, exhibited a consistently greater rate of body weight loss and significant brain acetyl-cholinesterase depression relative to control Canada Geese. These limited conclusions provide some further support to the Agency's concerns about diazinon's toxicity.

g. Bird Kills

In the previous sections, the Agency assessed the hazard to birds on golf courses and sod farms based on the acute toxicity of diazinon, estimates of exposure to diazinon residues, and estimates of dose levels consumed by birds. The results of this assessment indicated a hazard to birds, but was based solely on estimates. While these estimates are based on the best methods for estimating exposure levels, the Agency also has information concerning an extensive number of diazinon related bird kills, which validates that large numbers of birds are exposed to lethal diazinon residues.

Stone and Gradoni (1985) prepared a report which documented 54 bird kills associated with diazinon. Agency records contain several additional diazinon bird kills (Schobert, 1974; Steinke, 1978; Bennett, 1985; Faatz, 1985a and 1985b; Parnell, 1985). Many of these kills were associated with large grassy sites such as golf courses. Most of the kills involved waterfowl, which is to be expected because waterfowl generally feed in open areas where diazinon may be applied. Golf courses and other large grassy sites, such as sod farms, may be preferred feeding sites because they are stable and reliable sources of food. Golf courses are also important resting and feeding stops in portions of the major waterfowl flyways across the country. Golf courses, especially in populated and suburban areas, may be the only locally available suitable habitat for migrating birds.

The Agency's assessment of these bird kills (U.S. EPA, 1985g) considered only those incidents in which diazinon was clinically diagnosed as the cause of mortality or was strongly implicated. In most cases site inspection was conducted and environmental and/or bird carcass analysis was conducted to determine the levels of residues and cause of death. Anecdotal reports were not considered.

Table II-2 provides a summary of the kills which occurred on golf courses and other grassy sites such as lawns, recreational areas, or parks. In reviewing the information the Agency found that a large number of bird kills occurred throughout the country and throughout the year. Bird kills were not restricted to certain flyways or other geographic areas and were not limited to certain seasons or time of the year. The minimum number of individuals varied considerably from a few to 1000. The Agency has determined that this information verifies the chronic and wide-spread hazard to both individual birds and local populations.

Grazing birds such as waterfowl were involved in the 20 bird kills on golf courses and in 19 of the 20 kills which occurred on other grassy sites. This is predictable because waterfowl tend to graze in open areas where diazinon may be applied. However, the Agency feels that the true extent of the hazard to grazing birds is underestimated because of incomplete reporting. Birds that are exposed to diazinon will vary by location, season, and time of day, which will influence the likelihood of a kill being observed and reported. Also, some species form feeding flocks, while others forage singly. Kills involving flocks are more likely to be observed and reported, as opposed to those involving single birds. Thus, the number of birds and the number of reported incidents are much less than those actually reported.

Among the waterfowl kills both migratory and nonmigratory birds have been reported. In New York approximately 700 Atlantic Brant Geese were killed prior to their spring migration. (See section II.B.2.) Many smaller flocks of Canada Geese and Mallard Ducks have also been killed throughout the country. The following table summarizes several of these incidents (Parnell, 1985; Stone and Gradoni, 1985):

Month	State	Species	Number
April	New York	Atlatic Brant Geese	50-60
June	Michigan	Canada Geese	25
June	New York	Canada Geese	35
August	New York	Canada Geese	81
October	Connecticut	Mallard Ducks	25
December	California	American Wigeon	30

In the more southern regions of the country, some ducks and geese do not migrate further south in the winter, but remain in the same area year around. Such birds are likely to visit grassy sites such as golf courses and sod farms throughout the year. About 100 American Wigeon and American Coot were killed in December 1976 on a golf course in California. Some of these ducks were nonmigratory.

Table II-2. Summary of the Bird Kills on Golf Courses and Other Turf Sites

Occurrence	State	Site*	Species	Number of Individuals
January, 1972	California	gc	American Wigeon	800-1000
March, 1974	Florida	other	Swans and Ducks	26 +
April, 1979	New York	gc	Atlantic Brant Geese	50-60
April, 1981	New York	gc	Atlantic Brant Geese	19
May, 1980	New York	gc	Atlantic Brant Geese	31
May, 1984	Michigan	other	Canada Geese	6
May, 1984	New York	gc	Atlantic Brant Geese	700
June, 1974	New York	gc	Canada Geese	35
June, 1975	Massachusetts	other	Canada Geese	2 +
June, 1978	Michigan	other	Canada Geese	25
June, 1985	New York	gc	Canada Geese	4 +
June, 1985	California	gc	Canada Geese	3
July, 1974	New York	other	Canada Geese	12
July, 1982	Michigan	gc	Canada Geese	4
			Mallard Ducks	5
			Red-winged Blackbirds	3
July, 1977	New Jersey	other	Blue Jays, Common Grackles, and House Sparrows	42
July, 1982	Michigan	other	Canada Goose	1
July, 1984	Minnesota	other	Mallard Ducks	12
August, 1973	Connecicut	other	Canada Geese	31
August, 1979	New York	gc	Canada Geese	10
August, 1980	New York	other	Canada Geese	81
August, 1981	Virginia	gc	Canada Geese	24
August, 1982	Kentucky	gc	Mallard Ducks	11
August, 1983	Colorado	gc	Canada Geese	28
August, 1983	Michigan	other	Canada Geese	6
August, 1984	Michigan	other	Mallard Ducks	2
September, 1980	New York	other	Canada Geese	16
September, 1980	New York	other	Mallard Ducks	10 +
September, 1985	Indiana	other	Mallard Ducks	40
October, 1970	New York	other	Mallard Ducks	200
October, 1976	New York	gc	Canada Geese	24
October, 1978	Connecticut	gc	Mallard Ducks	25
October, 1983	Michigan	other	Canada Geese	18
November, 1975	Missouri	gc	Canada Geese	14
December, 1976	California	gc	American Wigeon and American Coot	100
December, 1983	California	gc	American Wigeon	30
July 1977 to October 1984	New Jersey	gc (2) other (3)	Canada Geese	32

* "gc" refers to golf courses and "other" refers to grassy sites other than golf courses.

Seed-eating, insectivorous, and omnivorous bird species are also documented as being killed by diazinon on golf courses, lawns, and other grassy sites. As indicated in table II-2 Red-winged Blackbirds, Blue Jays, Common Grackles, and House Sparrows are also known to be exposed to lethal doses of diazinon on golf courses and other grassy sites. The Agency believes that the hazard is underestimated for these birds as well, which are even less likely to be observed after lethal exposure to diazinon than waterfowl. First, they are generally smaller and less visible than waterfowl such as ducks and geese. Second, they do not tend to move in large, conspicuous flocks. Third, carcasses are more likely to be quickly removed by predators because of their small size. Fourth, the smaller bodies deteriorate more rapidly than the carcasses of larger birds. Lastly, smaller birds instinctively will seek brushy cover prior to death, unlike waterfowl who instinctively tend to move to water or open areas when they are sick or poisoned. As a result songbird carcasses are often hidden and less likely to be observed. These various factors combine to suggest probable under-reporting of songbird kills.

No bird kills have been reported for sod farms. However, the Agency considers that sod farms are also important forage sites for birds, especially waterfowl. The similarity of appearance between sod farms and golf courses suggests that birds will forage on sod farms and encounter diazinon residues on the grass and in irrigation puddles. The Agency believes that the absence of reported bird kills indicates incomplete reporting and lack of public observation on private sod farms. Private sod farms are associated with fewer people than golf courses, and thus fewer people are likely to observe bird kills.

As table II-2 indicates diazinon related kills have been reported from states all across the country. There is no apparent correlation with geographic location of bird kills and major migratory flyways for waterfowl. Birds have been killed on golf courses both inside and outside of the flyways. As noted previously nonmigratory waterfowl and resident songbirds have also been killed from diazinon on golf courses and other grassy sites throughout the country.

As summarized in table II-2, diazinon related kills have been reported for every month of the year but February. The Agency believes that this is also a result of incomplete reporting and not due to any unique events associated with this month. There is also no apparent correlation with time of year and geographic location of kills on golf courses and other turfgrass sites. The Agency concluded that the documented bird kills which have occurred throughout the country and throughout the year indicate that birds are in danger of lethal exposure during all seasons and not just in the migratory months of the year. The Agency also concluded that the hazard is not limited geographically, but is wide-spread and continuous throughout the country.

Field evidence taken from these bird kills supports Agency concerns that hazards from diazinon and other pesticides may be greater than indicated by laboratory toxicity measures alone. The Agency believes that wild birds may be exposed to more physiological stresses by being free-living and may be more susceptible to pesticide poisoning than captive laboratory birds. Agency records of residue levels obtained from birds diagnosed as being killed by specific pesticides show that bird body residues are consistently much lower than laboratory LC_{50} and LD_{50} values (Stone, 1979; FMC Corporation, 1983; Okoniewski, 1985).

Residues obtained from body analysis of birds diagnosed as having been killed by diazinon range from below 0.01 ppm to such representative values presented in table II-3. All fatalities listed on the table occurred on golf courses. These residue values were taken from Stone and Gradoni (1985), and the case numbers refer to the case numbers used in the report. Most of the body residue levels are less than the estimated daily dose for both grazing and seed-eating birds for all application rates. This indicates that birds may be more susceptible to diazinon poisoning than the hazard evaluation based on acute laboratory toxicity data indicates.

Residues found on grass samples taken from sites of bird kill are also lower than would be expected using standard exposure models (Kenaga, 1973). Stone and Gradoni (1985) report residues ranging from below 0.1 to 79 ppm in grass taken from the esophagus of freshly killed Atlantic Brant Geese. The highest grass and soil residues from a Mallard Duck lawn kill site was 141 ppm. Residues were obtained within six days of application (Bennett, 1985; Faatz, 1985a and 1985b).

The Agency recognizes that pesticides start to degrade and metabolize upon exposure in the environment and upon ingestion. Elapsed time from application and/or ingestion to freezing or stabilization of samples prior to analysis will also affect the residue levels obtained. While detailed information on diazinon residue persistence on grass and in tissues and organs is not available, the Agency finds it is reasonable to expect analytical values lower than laboratory LC_{50} and LD_{50} vlaues. Birds may be killed from LC_1 and LC_{10} values, for example. The slope of the dose-response line for technical diazinon is 6.5 and for 14 percent ai G formulation is 5.3 (Hill and Camardese, 1984). Therefore, some mortality may be anticipated at relatively low levels of diazinon exposure. However, in the New York instance where almost 100 percent of the exposed Atlantic Brant Geese were killed (Harmon, 1985; Stone and Gradoni, 1985), site and carcass residues were considerably lower than the LC_{50} values.

Table II-3. Residue Levels Taken from Body Analysis of Birds Diagnosed as Having Been Killed by Diazinon (Stone and Gradoni, 1985)

Species	Sample	Residue Levels (ppm)	Case Number
American Wigeon	liver	0.14	3
	gizzard	2.7	3
Mallard Duck	stomach	72	6
Canada Goose	esophagus	14	17
	grass in mouth	20	25
	grass in digestive tract	5.9	41
	gizzard	0.99	36
	liver	0.05	36
	gizzard	0.34	38
	liver	0.014	38
Atlantic Brant	gizzard	0.77	40
	liver	0.003	40
	small intestine	0.002	40
	gizzard	0.12	42
	liver	< 0.01	42
	gizzard	0.44	46
	gizzard	1.52	49

B. Significant Local Population Reduction

1. Introduction

EPA has determined that diazinon meets or exceeds the existing risk criterion in 40 CFR 162.11(a)(3)(ii)(C), which provides that a Special Review shall be conducted if the use of a pesticide "can reasonably be anticipated to result in significant local, regional, or national population reductions in non-target organisms, or fatality to members of endangered species."

On the basis of the scientific studies and other information reviewed by the Agency, EPA concluded that diazinon meets or exceeds this risk criterion and may result in unreasonable adverse effects to Atlantic Brant Geese. The following is a brief summary of the data upon which the Agency based its conclusions.

2. Hazard Evaluation

The Agency has reviewed information which indicates that diazinon has caused a significant reduction of a local population of Atlantic Brant Geese (Branta bernicla hrota) in New York. Atlantic Brant are classified as a species requiring either special or enhanced resource expenditures in the U.S. Department of Interior, U.S. Fish and Wildlife Service (USFWS) National Resource Plan (Almand, 1985). This classification of Atlantic Brant is based upon the large annual fluctuations of the populations, the lack of population stability, and other biological, political, social, and economic considerations.

On May 7, 1984, Diazinon AG500 was applied following label directions to three golf course fairways in Hempstead, New York. The fairways were then irrigated. As a result of the application, approximately 700 Atlantic Brant Geese died. Carcass analysis revealed that the birds died of acute diazinon poisoning (Harmon, 1985; Stone, 1985a; Stone and Gradoni, 1985). The New York wintering population of Atlantic Brant was estimated to be 2500 in 1984 (U.S. EPA, 1985f). The Agency considers this loss of 28 percent to be a significant local population reduction.

There are many sources of mortality that place pressure on the Atlantic Brant populations. Deaths from pesticide poisoning incidents, adverse weather conditions, loss of food sources, and hunting all play a role in placing stress on their survival. The Agency is concerned about these stresses because of the annual fluctuations of the Atlantic Brant, which are greater than those of most other waterfowl. Annual counts of Atlantic Brant populations

indicate dramatic shifts from year to year (Bellrose, 1976; Kirby and Obrecht, 1982). This extreme variability is because Brant reproductive success is largely determined by weather conditions in the summer breeding range. Atlantic Brant are a geographically restricted goose species that tend to nest further north in the Arctic than any other North American waterfowl (Bellrose, 1976; Palmer, 1976). In the Arctic summers are short and weather is extremely variable. Some some summers may be shortened further than normal by late spring thaws and/or early onset of harsh winter weather. Brant are only able to reproduce in relatively mild summer climatic conditions. Unfavorable climatic conditions are known to all but eliminate reproductive success of Atlantic Brant in some years (U.S. EPA, 1985f). Because Atlantic Brant populations fluctuate so widely, the total number of individuals consituting a given population in some years is very small (U.S. EPA, 1985f). When populations are small, loss of individuals becomes of greater importance than such losses would be to a larger population. When populations are small, incremental stress such as pesticide deaths may be of considerable importance in adversely impacting a population that is already stressed from other factors. The Agency is concerned that this may have happened to the New York wintering Atlantic Brant population of 2500 when approximately 700 were killed.

Winter mortality also stresses the local populations. Atlantic Brant winter along the Atlantic coast from Massachusetts to North Carolina, with the largest winter population along the New Jersey coast and the second largest among the bays of Long Island, New York (Bellrose, 1976; Kirby and Obrecht, 1982; U.S. EPA, 1985f). Winter survival is largely dependent upon weather conditions, especially winter storms and the timing of cold weather that freezes over the bays where Brant feed on eel grass and sea lettuce. When waters are frozen and submerged grasses are not available or when the winter is severe, Atlantic Brant will move inland to graze (Kirby and Obrecht, 1982; U.S. EPA, 1985f). At this time the birds are already severely stressed from reduced feeding and must deal with additional hazards in unfamiliar areas. For example, Atlantic Brant have been found feeding in small highway dividers during the winter.

Loss of a food source also places stress on a local population. Largely in response to the decline of the Atlantic Brant's major food, eel grass, the Atlantic Brant population in Barnegat Bay, New Jersey, declined from 28,800 in the winter of 1927-28 to 1980 by the winter of 1932-33. The population along the Atlantic Coast during the winter of 1933-34 was only 10 percent of that in 1930-31 (Bellrose, 1976; Kirby and Obrecht, 1982). As a partial result of the loss of eel grass sources, the Atlantic Brant changed food habits to include upland grazing on golf courses and other

open grassy areas, and populations increased in the late 1930's (Bellrose, 1976). Eel grass abundance along the eastern seaboard increased until the early 1970's, and many Atlantic Brant returned to feeding on eel grass. Then, eel grass again declined dramatically as a result of altered water quality, harmful levels of nitrogen and phosphorus, and other factors. The Brant populations also decreased significantly. Atlantic Brant population levels have never completely recovered from these declines (Kirby and Obrecht, 1982).

Another source of stress on the local populations is hunting. Because of the general decline in Atlantic Brant, the USFWS closed the hunting season for Atlantic Brant in 1972. Except for a single season in 1975, they remained closed until 1981 when the population increased and hunting was allowed again. In 1981 the USFWS opened an Atlantic Brant season for 30 days with a bag limit of two birds. By 1983 the season was expanded to 50 days, and in 1984 the bag limit was increased to four. The 1985 season will be 50 days with a bag limit of four.

Although the Atlantic Brant are hunted at this time, the USFWS is still concerned over the stress that hunting places on the Brant. USFWS intensively monitors the local populations to detect decreases. Its goal is to maintain population stability within the wide fluctuations and to provide traditional, established hunting seasons for the Brant and other waterfowl. USFWS will close hunting seasons to protect an unstable population, but usually only as a last resort. USFWS also seeks to provide safe and high quality habitats for wintering Atlantic Brant. This is an important management technique and helps buffer winter populations from additional stress and mortality (U.S. EPA, 1985f).

As indicated previously, the Agency is concerned over the various stresses placed on the Atlantic Brant population. While the harsh Arctic environment plays a major role in the Atlantic Brant's reproductive success, winter mortality along the eastern seaboard may be highly influential as well. These stresses, as well as hunting, are not within Agency control. The Agency does have the authority, however, to protect non-game bird populations such as the Atlantic Brant from the adverse effects from pesticides. Given the tenuous recovery that Brant populations have shown in the past, any additional stresses such as deaths from diazinon poisoning could have a negative impact and should be eliminated, if possible.

The Agency has further cause for concern because the population of Atlantic Brant wintering along the New York coastline are considered unique and may help provide genetic variability to the species (Abraham et al., 1983; Novak et

al., 1985; Smith et al. 1985; Vangilder and Smith, 1985). Some waterfowl, especially geese, tend to remain in family groups throughout their lives, migrating and remaining together on their breeding and wintering grounds. This characteristic is sufficiently dependable that some local populations of waterfowl are tracked and patterns of population growth and decline are documented (Bellrose, 1976).

Because of the tendency to remain together, local populations tend to interbreed, although breeding with other local populations does occur. These local populations are adapted to environmental conditions in their area. Other local populations would not be as well adapted to survive in the localized environment as the local population that evolved there. Although local populations such as the affected one in New York are the same species as the national population, they are still considered at least partially genetically distinct and help provide the species with genetic variability.

Loss of genetic variability is a contributing cause of species extinction. For a species to remain viable, the genes from local populations are needed to assure genetic variability so that some portion of the national population can adapt to catastrophic or rapid environmental change. Since such changes generally cannot be predicted, it is not possible to predetermine which unique set of genes and their associated characteristics will be important in a new environment. It is important for the preservation of a species to maintain enough genetic variability so that one or more of the local populations will survive environmental change.

III. BENEFITS ANALYSIS

A. Introduction

Diazinon is a broad-spectrum insecticide registered for a variety of agricultural and nonagricultural sites. Included are golf courses and sod farms, which are the sites of concern of this Special Review and Preliminary Determination. Diazinon is used throughout the United States to control insect pests of golf courses and sod farms.

The general approach of this analysis was to (1) review the biology of the insect pests and their control, and (2) to evaluate the user cost impacts of cancellation of diazinon. This impact would cause users to shift to alternative insect control measures. The alternatives for diazinon on golf courses and sod farms were chosen on the basis of cost and market availability.

Cancellation of diazinon on golf courses and sod farms would result in an average annual increased cost of $937,200 on golf courses and $300,000 on sod farms. These impacts are based on increased costs of insect control. In calculating these impacts, the Agency assumed that only currently registered pest control methods on golf courses and sod farms would be available at the time of cancellation.

B. Biological Assessment of Sites of Concern

The Agency reviewed information concerning the insect pests on golf courses and sod farms and their control (U.S. EPA, 1985d and 1985i).

1. Primary Turf Pests

The three major groups of primary turf pests are (1) soil inhabitants, such as white grubs and mole crickets; (2) thatch inhabitants, such as chinch bugs, sod webworms, crane fly larvae, and billbug adults; and (3) stem and leaf inhabitants, such as aphids and certain mites. Diazinon is used to control a variety of these pests.

White grubs are the larval stage of many species of beetles such as the Japanese beetle, Popillia japonica Newman and the Black turfgrass ataenius (BTA), Ataenius spretulus (Haldeman). The bluegrass billbug, Sphenophorus parvulus Gyllenhal and several other species of billbugs are closely related. Damage to turf is primarily due to larval feeding. However, adult beetles, particularly billbug adults, can be injurious to turf.

The life cycle of the Japanese beetle is typical of white grubs. White grubs overwinter in the soil. They feed mainly on decaying vegetation, but also on the fine roots of grasses and other plants. Insecticide application is timed to coincide with active feeding near the soil surface in March and April or late July and September. A single treatment is normally adequate, but occasionally additional applications are needed. The adults emerge in August. White grubs are distributed throughout the United States, although there are variations in the distribution of some species (Metcalf and Flint, 1951; Niemczyk, 1984).

Two species of chinch bugs with similar life cycles are considered important pests of turf. The hairy chinch bug, Blissus leucopterus hirtus Montandon, is a pest of northern turfgrasses. The southern chinch bug, Blissus insularis Barber, is a pest in the South. Chinch bugs hibernate as adults and remain in hibernation until April in the South and May and June in the North. Generally one insecticide treatment is made at this time. A second or third application may be made if populations are unusually large. Damage to grasses results from the feeding of nymphs and adults. Chinch bugs are found throughout the United States, southern Canada, Mexico, and Central America. The areas of greatest damage are in the Mississippi, Ohio, and Missouri River Valleys (Short and Reinert, 1980; Shetlar et al., 1983).

Sod webworms include a complex of species. Adults are small moths that do not damage turf, and the larvae are caterpillars that feed on grass. If feeding is extensive during dry weather, the plants may be killed. The most common species on northern turfgrass has two generations each year and overwinters as larvae. In southern climates several overlapping generations per year may occur. Generally two treatments are made in April in the South and May and June in the North. Three and four treatments are made when populations are unusually large (Niemczyk, 1981).

The European crane fly, Tipula paludosa Meigen, is becoming a serious turf pest in the Pacific Northwest. The flies emerge from the soil of grass areas from late August to mid-September, mate, and lay eggs in grass. Eggs hatch into larvae, which feed on the root crowns of grasses during the fall and into winter, when they become dormant. They feed again in spring as the weather warms. Treatment is most effective during early April and may continue through summer, depending upon the extent of the damage. However, fall applications when the larvae are small are recommended for golf courses (Antonelli, 1984).

There are three species of mole crickets which may constitute a problem in turf. They are (1) the changa or Puerto Rican Scapteriscus vicinus Scudder; (2) the southern mole cricket, S. acletus Rehn and Hebard; and (3) the S. abbreviatus Scudder. The changa and southern species are pests of major importance on most grasses grown in the southeastern United States. All stages feed on grass roots. Damage is especially severe in newly planted turf. Insecticides may be applied anytime from spring through fall, depending on the severity of the damage (Short and Reinert, 1980; Niemczyk and Cobb, 1985).

2. Turf Pest Control

Efforts to find alternatives to chemical control have been made by researchers working in turf. For example, research is being conducted to identify turfgrass varieties that are resistant to insect injury. Avoiding use of susceptible turf varieties and encouraging use of varieties with resistance reduces the need for treatment.

Despite cultural control advances, chemical control remains the main defense against turf pests. The five major alternatives to diazinon are chlorpyrifos, carbaryl, trichlorfon, isofenphos, and bendiocarb. Diazinon and its major alternatives are applied using ground equipment to golf courses and sod farms. Granular formulations are applied by a broadcast spreader, which is mounted on a truck, tractor, trailer, or golf cart. Liquid formulations are applied by either boom or airblast sprayer. They may also be mounted on a tractor, trailer, or truck. After application the G formulations are irrigated in and may be brushed in. The L formulations may also be irrigated, depending on the pest.

A review of the State recommendations (Hellman, 1978; Vasvary, 1978; Short and Reinert, 1980; Shetlar et al., 1983; Kissam, 1984; Petrovic et al., 1984; Brandenburg and Baker, 1985; Capizzi et al., 1985) indicates that not all of the alternatives are recommended for control of each of the major pests. The following table indicates, in general, which insecticide is recommended for control of the chinch bug (CB), grub (G), billbug (BB), mole cricket (MC), European crane fly (ECF), and sod webworm (SW). There is some variation on regional basis.

Insecticides Recommended for Control of Major Turf Insects

Pesticide	CB	G	BB	MC	ECF	SW
Diazinon	+	+	+	+	+	+
Bendiocarb	+	+	+	+	-	+
Carbaryl	+	+	+	+	-	+
Chlorpyrifos	+	+	+	+	+	+
Isofenphos	+	+	+	+	-	+
Trichlorfon	-	+	-	-	+	+

+ = recommended
- = not recommended

The application rates for diazinon and its alternatives presented in the following table as a single number are based on State recommendations (Hellman, 1978; Vasvary, 1978; Short and Reinert, 1980; Shetlar et al., 1983; Kissam, 1984; Petrovic et al., 1984; Brandenburg and Baker, 1985; Capizzi et al., 1985). These numbers may be the minimum or maximum label rate, or an application rate in between. Those which appear as a range are the minimum and maximum label application rates.

Application Rates (lb ai/A)

Pesticide	CB	G	BB	MC	ECF	SW
Diazinon	3-8	6	6	6	6	6
Bendiocarb	1-2	2-4	2-4	2-4	-	1-2
Carbaryl	13	13	9	1-2 (bait)	-	9
Chlorpyrifos	1	2-4	2-4	1 (bait)	1-4	1
Isofenphos	1-2	2	2	2	-	1-2
Trichlorfon	-	8	-	-	5-8	6-8

- = not recommended

C. Benefits Analysis for Golf Courses

The Agency estimated the benefits of diazinon application to golf courses (U.S. EPA, 1985b). The analysis was based on a final report concerning a national survey of pesticide usage on golf courses (Kriner, 1985), which was conducted by the American Association of Retired Persons. This survey provided an extensive data base concerning insecticide usage based on EPA Regions.

In 1980 there were 12,788 golf courses with an estimated acreage of 1,286,000. The average golf course is 120 acres. The tees and greens, which account for the most intensive pesticide treatments, represent about 3 percent of the golf course. Fairways are also treated and account for about 37.5 percent of the golf course. Thus, about 40 percent of the average golf course is treated with pesticides.

The estimated total maintenance cost of these courses is $1,900,000,000 with $96,000,000 for pesticide purchases. The average budgets for maintenance and pesticide expenditures for an individual golf course varies considerably from one area of the country to another. Different climates and soil types will affect the turf condition and pest infestation problems. This will determine the need for certain chemicals and the level of course maintenance. Also, differences in the length of the playing season will affect the course maintenance costs.

Annually, the total lb ai/A of insecticide use on golf courses is estimated to be 1,571,866 pounds. The following table summarizes the usage of diazinon and its alternatives:

Usage of Diazinon And Its Alternatives on Golf Courses

Pesticide	lb ai	Percent of Total
Diazinon	512,112	33
Isofenphos	347,718	24
Trichlorfon	215,975	14
Carbaryl	144,301	9
Chlorpyrifos	91,885	6
Bendiocarb	393	0
Others	259,482	14
	1,571,866	100

Diazinon dominates the market and is used by 51 percent of all golf courses and accounts for an estimated 102,422 acre treatments. The Agency estimates that diazinon is used to treat an average of 14 percent of a golf course. However, the actual use of individual insecticides varies across the country. Diazinon is not the leading pesticide for all areas of the country. Regional differences result from the different pest problems across the Nation. Diazinon is the leading pesticide in the Southeast and the West. However, the West accounts for only 3 percent of total pesticide use.

The Agency estimated the costs per pound of applying diazinon and its alternatives. The cost was based on wholesale price lists. Average prices were used since prices varied among wholesalers.

Average Prices for Diazinon and Its Alternatives

	Price ($) / lb ai	
Pesticide	Granular/ Wettable Powder	Liquid
Diazinon	8.00	8.25
Isofenphos	27.50	31.00
Trichlorfon	6.98	N/A
Carbaryl	4.65	N/A
Chlorpyrifos	16.00	22.00
Bendiocarb	33.00	N/A

Using this information the Agency estimated the costs per acre of applying diazinon and its alternatives. The analysis was based on the following assumptions:

- The only cost differences are from the product costs since similar application techniques would be used regardless of the chemical being applied.
- The cost per acre is based on the minimum application rate, except when a recommended rate was given.
- The most cost-effective formulation was used when alternatives by formulation type were identified.
- Regional increases in the average cost per acre are based on substituting mainly chlorpyrifos in the West and isofenphos in the East. These have been the major alternatives in the past based on the golf course survey. Key target pests influencing application rates are grubs, chinch bugs, and mole crickets.

The analysis of increased pesticide cost is summarized in table III-2. There were four key components used in this analysis: The first was the substitution of alternative chemical controls by EPA Region, the second was the key target pests in each Region, the third was the application rate for the particular pest, and the fourth was the cost per pound of active ingredient.

The estimated increased cost from diazinon cancellation is $937,200. This represents a minor impact to golf course operations budgets and golfers. The increased cost of diazinon cancellation for the nation is 1 percent of pesticide purchases or $96,000,000 and 0.05 percent or $1,900,000,000 of all course maintenance expenditures. The total cost for the 13,000,000 golfers who each play more than 15 rounds per year is $0.07 per year. Thus, the impacts from the diazinon cancellation are minor considering the operating budgets of golf courses or the potential impact on golfers.

D. Benefits Analysis for Sod Farms

The Agency has estimated the benefits of diazinon on sod farms (U.S. EPA, 1985c). Unlike golf courses, the data base was extremely limited and, as a result, the analysis was based solely on a comparison of the cost of using diazinon and other major turf insecticides.

The sod industry in the United States annually harvests 123,000 acres of sod for a gross revenue of $210,000,000. Adrian et al. (1981) estimates that an acre of sod costs $900 to produce. During any given year 280,000 acres of sod are under production and approximately 6 percent or 16,800 acres are treated with a total of 60,000 pounds of diazinon. White grubs appear to be the most important pest.

The largest turf producing States are Florida, Texas, Minnesota, Colorado, Michigan, and California. Regionally, the Southeast has the greatest number of acres, revenues, and usage of diazinon. In the Southeast, 8400 hundred acres are treated annually. The West follows with approximately 5800 acres treated. The Northeast and Midwest split the remaining usage evenly with 1260 acres treated in each area.

Table III-1. Summary of the Economic Impact of Cancellation of Diazinon on Golf Courses*

	All Regions	EPA Region 1	EPA Region 2	EPA Region 3	EPA Region 4	EPA Region 5	EPA Region 6	EPA Region 7	EPA Region 8	EPA Region 9	EPA Region 10
Golf Course Acres Treated With Diazinon	102,422	3,317	5,779	11,716	31,283	23,416	11,298	2,372	4,160	5,309	3,633
Increased Cost ($)/Acre	9.15	9.36	9.36	5.98	17.15	6.74	1.29	9.55	16.01	(1.81)	(1.81)
Increased Cost ($)/ Year	$937,200	31,000	54,100	70,000	536,600	157,900	14,600	22,600	66,600	(9,600)	(6,600)
Cost Increase As a Percentage of Purchases	0.9	0.9	0.5	0.7	1.9	0.8	0.1	0.4	4.7	(0.3)	(0.7)
Cost Increase as a Percentage of Maintenance	0.05	0.05	0.03	0.04	0.1	0.05	0.01	0.02	0.08	(0.0)	(0.02)

* Numbers which appear in parentheses are negative.

The following table summarizes the usage of diazinon and its alternatives:

Usage of Diazinon and Its Alternatives on Sod Farms

Pesticide	lb ai	Percent of Pesticide Market on Sod Farms
Diazinon	60,400	45
Carbaryl	59,800	44
Chlorpyrifos	6,500	5
Isofenphos	1,600	1
Bendiocarb	1,500	1
Trichlorfon	1,300	1
Others.	3,900	3
Total	135,000	100

Diazinon and carbaryl dominate the insecticide market for sod farms. Both are broad-spectrum insecticides and are relatively inexpensive. Isofenphos and bendiocarb are becoming more important because they are viewed as being more effective against particular pest problems.

The Agency estimated the costs per acre of applying diazinon and its alternatives. These estimates are summarized in table III-2. The analysis was based on the following assumptions:

- The economic impact of cancellation is determined solely by the cost to the applicator of the alternative insecticides. Sincer similar application techniques would be used regardless of the chemical being applied, no appreciable economic impact would result from applying diazinon or alternative pesticides.
- Minimum and maximum application rates are used for control of the major pests on sod farms. Detailed information concerning regional use patterns were not available and as a result minimum and maximum rates were used.
- Only the common agricultural formulations of the major registered alternatives are used.
- The alternatives are equally efficacious within registered rates.

Table III-2. Summary of the Economic Impact of Cancellation of Diazinon on Sod Farms

Pesticide	Cost($)/ lb ai	$ Per Acre Cost Minimum	$ Per Acre Cost Maximum	Range in Cost Difference Per Acre ($)	Average Cost Difference Per Acre ($)
Diazinon	8.00	22	66	--	--
Bendiocarb	33.00	43	178	21 to 113	66.95
Carbaryl	4.65	40	60	-5 to 19	6.85
Chlorpyrifos	22.00	22	88	0 to 22	11.40
Isofenphos	27.50	28	55	-11 to 6	-2.35
Trichlorfon	6.98	39	56	-10 to 17	3.86

In most cases the alternatives are more expensive. However, if an applicator routinely applied diazinon at maximum rates, the cost of changing to the alternatives would likely not be as great. Bendiocarb at maximum rates is extremely expensive and probably would not be used unless the lower rates were effective or local conditions precluded the use of other chemicals. Using the average per acre impact and the total number of acres treated, the total cost of replacing diazinon with the major alternatives is as follows:

Bendiocarb	$1,124,358
Carbaryl	115,081
Chlorpyrifos	191,452
Isofenphos	-39,466
Trichlorfon	64,892

The range of cost to the sod industry from the cancellation of diazinon is estimated to range from a cost decrease of $39,000 to a cost increase of $1,120,000, with a total average impact of $300,000 or approximately 0.14 percent of total gross revenues.

If diazinon was removed from the market, no one alternative would be the substitute of choice. It is more likely that each of the alternatives would experience increased usage.

Cost increases of the magnitude estimated should not severely affect most growers when compared to the $210,000,000 gross revenue of sod farms. It is possible that some individual growers may be more severely affected than others because of particular pest problems. In addition, different areas of the country will be affected in different ways. The West and South will be more severely affected than other regions because a higher percentage of the total acres in those regions are treated with diazinon. In the West, however, the per acre value of the sod is greater than in any other region, which lessens the severity of the impact. This is not true in the South, where sod has a value slightly less than the United States average. Thus, the southern sod producers may be more severely affected than producers in the West.

IV. REGULATORY OPTIONS AND RISK BENEFIT ANALYSIS

A. Introduction

FIFRA requires the Agency to weigh the risks against the benefits for the pesticide uses of concern to determine whether continued registration would cause unreasonable adverse effects on the environment. In Chapter II the Agency described the risks posed by exposure of birds to diazinon on golf courses and sod farms. In Chapter III the Agency identified the major alternative pesticides for golf courses and sod farms and described the benefits.

To determine whether continued registration of diazinon on golf courses and sod farms is appropriate, this section reviews the Agency's conclusions concerning the risks and benefits of diazinon and its alternatives. This section also identifies the regulatory options available to the Agency to reduce the risks from diazinon's use on golf courses and sod farms. Each option has been evaluated for its impact on the risks and benefits of the registered uses of diazinon, and the most appropriate regulatory options have been proposed. The avian and human risks of the alternative pesticides have also been summarized.

B. Risk Conclusions

1. Acute Toxicity of Diazinon

The Agency evaluated acute toxicity studies which indicated that diazinon is very highly toxic to birds. To evaluate this acute hazard, the Agency estimated residue levels on grass and seed to determine if the values would exceed the LC_{50} for grazing and seed-eating birds. The Agency also estimated the dose of diazinon that waterfowl or seed-eating birds would consume from residues on grass and seed to determine if the values would exceed the LD_{50}. Both residue level and dose estimates exceeded the toxicity measures for certain species and thus exceeded the risk criterion for Special Review.

The Agency also compared the LD_{50} values for individual granules to the number applied per square foot. The results indicated that hazardous exposure for any bird exists within a single square foot of turf.

The hazard described by these estimates is confirmed by the number of bird kills that have resulted from diazinon application. Approximately 60 bird kills have been reported to the Agency in which diazinon was either confirmed or implicated as the primary cause of death. These kills have

involved 23 species of birds, including migratory and nonmigratory waterfowl, songbirds, and others. Twenty of these kills have occurred on golf courses and 20 on other grassy sites. These kills have occurred during all months of the year and have been documented from the East to the West coasts throughout the country.

The Agency concluded that diazinon met the risk criteria for acute effects and may result in unreasonable adverse effects to birds on golf courses and sod farms.

2. Significant Local Population Reduction

The Agency has also reviewed information which indicates that diazinon caused a significant reduction of a local population of Atlantic Brant Geese in New York. Diazinon was applied and irrigated according to label directions to a golf course in New York. As a result approximately 700 Atlantic Brant Geese died. Carcass analysis revealed that the birds died of acute diazinon poisoning. The New York population of Atlantic Brant Geese was estimated to be 2500 in 1984. The Agency considers this loss to meet the significant local population reduction risk criterion. Thus, diazinon use on golf courses and sod farms may constitute an unreasonable adverse environmental effect.

3. Risks from the Alternatives

The major chemical alternatives to diazinon are listed in Chapter III of this document. The Agency has reviewed information concerning the risks of these major diazinon alternatives to birds and humans, as follows.

a. Avian Toxicity

The Agency reviewed information concerning the avian risk of the major diazinon alternatives (U.S. EPA, 1985a). The following table lists the acute toxicity values for the Bobwhite Quail and Mallard Duck from diazinon (Hill and Carmardese, 1984). Also listed are the acute toxicity values for (1) isofenphos (Mobay Chemical Corporation, 1978a; 1978b; 1981), (2) chlorpyrifos, (3) trichlorfon, (4) bendiocarb, and (5) carbaryl (Hill et al., 1975; Hudson et al., 1984).

Insecticide	Bobwhite Quail LD_{50} (mg/kg)	Bobwhite Quail LC_{50} (ppm)	Mallard Duck LD_{50} (mg/kg)	Mallard Duck LC_{50} (ppm)
Isofenphos	8.7	145	data gap	1000
Diazinon	10	245	3.5	191
Chlorpyrifos	13.3	423	75.6	136
Trichlorfon	22.4	720	36.8	> 5000
Bendiocarb	19	1770	3.1	477
Carbaryl	> 2000*	> 5000	> 2179	> 5000

*Based on the California Quail

Like diazinon, the acute toxicity measures indicate that several of the alternatives are relatively acutely toxic to birds. To evaluate the hazard to birds from these alternatives, the Agency estimated residues on short grass and seeds, immediately following application and 6 weeks later. The assumptions and method of calculation are the same as used for diazinon and are described in chapter II. These estimates were compared to the estimated residues on grass and seed from diazinon application. The maximum label rate for use against any major turf pest was used. Higher application rates for minor turf pests are registered for some of the alternatives, and rates also varied for specific major turf pests. To conduct a comparative assessment, the maximum rate allowed for any major turf pest was used for each alternative. The Agency did not attempt to account for repeat applications, amount or timing of irrigation, or other differences in use directions. The results of Agency estimates are summarized in table IV-1.

The estimates in table IV-1 were compared to the LC_{50} for Bobwhite Quail and the Mallard Duck. With the exception of chlorpyrifos and bendiocarb, none of the estimated residues immediately following application of the alternatives exceed the respective LC_{50}'s for the Mallard Duck. The chlorpyrifos and bendiocarb residues exceeds their respective Mallard Duck LC_{50} by a smaller magnitude than diazinon. Neither diazinon nor its alternatives exceed any of the Bobwhite Quail LC_{50}.

The Agency also estimated the dose birds could consume from eating residues of the alternatives on grass and seed. The assumptions and method of calculation are the same as used for diazinon and are described in Chapter II. The results are summarized in table IV-2.

Table IV-1. Estimated Residues (ppm) on Short Grass and Seeds for Diazinon and Its Major Alternatives

Insecticide (lb ai/A)	Residues on Short Grass (ppm) Average	Residues on Short Grass (ppm) Maximum	Residues on Seeds (ppm) Average	Residues on Seeds (ppm) Maximum
Diazinon EC (8)				
-immediately following	1000	1920	24	96
-6 weeks later	40	240	0.8	12
Diazinon G (6)				
-immediately following	750	1440	18	72
-6 weeks later	30	180	0.6	9
Isofenphos (2)				
-immediately following	250	480	6	24
-6 weeks later	10	60	0.2	3
Chlorpyrifos (4)				
-immediately following	500	960	12	48
-6 weeks later	20	120	0.4	6
Bendiocarb (5)				
-immediately following	625	1200	15	60
-6 weeks later	25	150	0.5	7.5
Trichlorfon (8)				
-immediately following	1000	1920	24	96
-6 weeks later	40	240	0.8	12
Carbaryl (13)				
-immediately following	1625	3120	39	156
-6 weeks later	65	390	1.3	19.2

Table IV-2. Estimated Dose (mg/kg) of Pesticide Consumed By Grazing Waterfowl and Seed-Eating Birds Based on Body Weight and Residues on Grass for Diazinon and Its Major Alternatives

Insecticide (lb ai/A)	Residues on Short Grass (mg/kg) Average	Maximum	Residues on Seeds (mg/kg) Average	Maximum
Diazinon EC (8)				
-immediately following	201	386	0.36	1.44
-6 weeks later	8	48	0.01	0.18
Diazinon G (6)				
-immediately following	151	289	0.27	1.08
-6 weeks later	6	36	0.01	0.14
Isofenphos (2)				
-immediately following	50	96	0.09	0.36
-6 weeks later	2	12	0.003	0.04
Chlorpyrifos (4)				
-immediately following	101	193	0.18	0.72
-6 weeks later	4	24	0.006	0.09
Bendiocarb (5)				
-immediately following	126	241	0.22	0.9
-6 weeks later	5	30	0.008	0.1
Trichlorfon (8)				
-immediately following	201	386	0.36	1.44
-6 weeks later	8	48	0.01	0.18
Carbaryl (13)				
-immediately following	327	627	0.58	2.34
-6 weeks later	13	78	0.02	0.29

The results in table IV-2 were compared to the LD_{50} values for the Bobwhite Quail and the Mallard Duck. Chlorpyrifos, bendiocarb, and trichlorfon residues all exceed the Mallard Duck LD_{50} but exceed it by a smaller margin than diazinon.

Although it is applied at a higher rate than diazinon and results in higher residues, carbaryl does not exceed the LD_{50} values. Carbaryl is much less toxic to birds and exposure to high carbaryl residues is likely to be less hazardous than avian exposure to the lower estimated residues of diazinon. Trichlorfon results in the same level of residues as diazinon, but it is less acutely toxic.

Three bird kills are associated with chlorpyrifos. In the first incident, 75 robins were killed following a single home use at 1 lb ai/A in January 1981 (Hill and Reichel, 1981). Specimens were analyzed and chlorpyrifos residues were found in the gastrointestinal tract. The second incident involved four robins, which died after chlorpyrifos application to a home lawn (Stone, 1985). Necropsy results indicated chlorpyrifos poisoning. The third incident involved four Canada Geese, which died while feeding and foraging on a golf course treated with chlorpyrifos and diazinon (Stone, 1979). Tissue and organ specimens were analyzed and contained trace amounts of the two insecticides. The Agency does not know if any of these incidents were the result of misuse or if proper label directions were followed.

The Agency has no reports of bird kills associated with the use of bendiocarb, carbaryl, isofenphos, and trichlorfon.

The Agency is concerned over these estimates because the major alternatives appear hazardous to birds as well. However, documented bird kills, a major line of evidence in the diazinon hazard evaluation, are generally lacking for the alternatives. These alternatives are used on golf courses and sod farms, but few kills have been reported. The Agency believes that bird kills on these grassy sites are equally likely to be reported, regardless of the pesticide involved. As a result the Agency has concluded that the currently available data indicate that the alternatives are not likely to pose a greater hazard to birds than diazinon. As additional information is received and reviewed for the alternatives, the Agency will determine whether or not to take regulatory action for any of the alternatives.

b. Human Toxicity

The Agency also considered the human toxicity of diazinon and its alternatives. Exposure may occur to applicators from treatment to a sod farm or golf course or to golfers playing on a treated course. The Agency has reviewed data on the oncogenicity, mutagenicity, reproductive effects, and teratogenicity/fetotoxicity to evaluate the potential toxicity (U.S. EPA, 1985j). The results are as follows:

Chronic Toxicity of Diazinon And Its Alternatives

Insecticide	Onco	Terato	Repro	Muta	Regulatory Status
Diazinon	-	-	-	?	SR initiated for avian hazard on golf courses and sod farms
Bendiocarb	?	-	-	?	DCI issued on 9/28/84
Carbaryl	-	-	-	-	RS issued on 3/30/84
Chlorpyrifos	-	-	-	-	RS issued on 9/30/84
Isophenfos	-	-	-	-	DCI issued on 8/30/84
Trichlorfon	?	-	-	+/-	RS issued 6/30/84

\+ = positive effects
\- = negative effects
? = not known at this time

SR = Special Review
RS = Registration Standard
DCI = Data Call-In Letter

Based on the available data, the major alternatives do not appear to pose a greater human health hazard than diazinon.

C. Benefits Conclusions

The benefits of diazinon were assessed in terms of economic impacts which would result if its uses on golf courses and sod farms were cancelled and users were forced to use the available alternatives. As described in Chapter III, registered alternatives exist, but in some cases the alternatives may be more expensive.

Approximately six percent of sod farms are treated with diazinon. If diazinon was removed from the sod farm market, no one alternative would be the substitute of choice. Each of the alternatives would likely experience increased usage, depending on the area of the country and the pests. The impact is estimated to be a cost increase of $300,000 for sod farms or about 0.14 percent of total gross revenues. This does not appear to be a major impact on the industry as a whole, which annually has a gross revenue of $210,000,000. However, individual growers or different areas of the country may be more affected than others.

Concerning golf courses, diazinon is used to treat 14 percent of the total acres of all golf courses. The estimated increased cost per year if diazinon is cancelled is $937,200 per year. The increased cost impact does not appear to be a major impact compared to the total maintenance cost of $1,900,000,000, and the $96,000,000 spent on pesticide purchases. The increased cost of diazinon cancellation for the nation is 0.05 percent of all course maintenance expenditures, and 1 percent of pesticide purchases. The total cost for the 13,000,000 golfers is $0.07 per year.

D. Comments on the Initiation of the Special Review

Prior to the initiation of a Special Review, registrants of manufacturing-use products are notified of the Agency's determination that the criteria to initiate a Special Review may have been met. This notification includes information on toxicity findings and other related general information. The Agency gives registrants 30 days from receipt of the notification to respond.

In response to the Agency's notification that a Special Review of diazinon on golf courses and sod farms was being considered, Ciba-Geigy Corporation proposed amending their product label with additional precautionary statements. These label changes were based on their field studies (Ciba-Geigy Corporation, 1983a and 1983b) and attempted to reduce avian risks and prevent the Special Review. Ciba-Geigy also provided a chronology of events and communications with the Agency relevant to the diazinon a[illegible]an hazard.

The Agency has determined that the proposals submitted by Ciba-Geigy do not rebut the Agency's presumption against diazinon. First, the field studies are invalid because of problems associated with their experimental design. (See Section II.A.3.) These studies do not demonstrate that the hazard associated with diazinon use on golf courses and sod farms can be reduced. Second, labeling also does not mitigate

the hazard to birds because birds could be killed regardless of label warnings. (See Chapter IV.E.1.) Third, the chronology of events and communication are irrelevant to the Special Review concerns.

E. Development of Regulatory Options

There are three basic options for regulating the use of diazinon on golf courses and sod farms:

Option 1 - Continuation of registration without changes,

Option 2 - Continuation of registration with modifications to the terms and conditions of registration, and

Option 3 - Cancellation of registration.

Adoption of option 1 would be appropriate when the Agency has concluded that the level of risk is acceptable compared to the benefits of use and that further risk reduction measures are not necessary to assure that the use of the pesticide meets the statutory standard for continued registration. Adoption of option 3 would be appropriate when the Agency has concluded that the risks from a use outweigh the benefits of that use. In this case these risks cannot be mitigated to an acceptable level when compared to the benefits by any other measures short of cancellation.

Option 2 is appropriate when the risks of a pesticide use can be reduced to a level where the benefits of use outweigh the risks. This risk reduction is accomplished by modifying the terms and conditions of the pesticide's registration. These modifications, which are usually expressed through the pesticide's labeling, are generally changes in the way the pesticide is used. These changes are designed to reduce exposure to the pesticide and thus reduce or eliminate the risk from the pesticide. In the discussion that follows, risk reduction measures that the Agency considered are evaluated for their potential effectiveness and feasibility.

1. Adding Label Precautionary Statements

Ciba-Geigy Coporation has proposed label changes concerning the acute toxicity of diazinon to birds and the hazards of improper irrigation. The registrant claims that the modifications in labeling will reduce the potential hazard to birds.

The Agency has determined that label warnings concerning the hazard to birds will not mitigate the hazard for several reasons (U.S. EPA, 1985h). First, birds, especially waterfowl, regularly feed on golf courses and sod farms. A warning suggested by Ciba-Geigy that birds may be killed does nothing to protect birds or to otherwise mitigate lethal exposure, and in some cases even domestic flocks were killed as a result of diazinon application (Faatz, 1985a and 1985b; Stone and Gradoni, 1985). Second, the knowledge that birds may be killed may deter some but not others from applying diazinon when birds are visibly present. Third, others may not even be aware of the presence of birds and proceed to apply diazinon. Fourth, an applicator could apply diazinon when birds are not present, only to have birds fly in and feed on the grass after it has been treated. The applicator who sprayed the golf course in New York on May 7, 1984, thought that the wintering Atlantic Brant had left the golf course to migrate north (Harmon, 1985; Stone, 1985a). The birds returned after diazinon was applied and approximately 700 were killed.

The Agency has also determined that label warnings concerning irrigation will also not mitigate the hazard. Ciba-Geigy proposes that applicators apply a minimum of 0.25 inches of water immediately after application, but to stop irrigation before puddling occurs. An applicator could attempt to irrigate properly, but because of contours in the landscape or the type of soil, puddling could still occur. Golf courses are deliberately constructed to feature slopes, rises, and valleys. The Agency is aware of the difficulties in achieving proper irrigation, and bird kills are associated with puddling (Faatz, 1985a and 1985b; Stone and Gradoni, 1985).

2. Limiting Diazinon Application to Certain Months

The Agency considered limiting diazinon application to golf courses and sod farms to certain months of the year when waterfowl have completed their spring and fall migration. Some waterfowl migrate at certain times of the year and by not allowing the application of diazinon during these times the hazard to waterfowl may be reduced. The Agency believes that while such a measure may reduce the hazard for certain migrating waterfowl, it will not reduce the hazard for other migrating and non-migrating waterfowl, and other birds.

Migrating waterfowl do tend to migrate at certain times of the year, but the timing will vary annually, depending on climatic conditions, food abundance, and habitat quality. In some years migration may be delayed or advanced several months over the time it occurred in the preceeding year. Records of bird kills from diazinon indicate that in one very

large kill of approximately 700 Atlantic Brant Geese (Harmon, 1985; Stone and Gradoni, 1985) the golf course management thought that the Brant had left to migrate north. Instead the birds returned to feed and as a result 28 percent of the local population were killed. The Agency concludes that it is not feasible to determine safe months when migrating ducks and geese are not at risk of lethal exposure.

Some ducks and geese are non-migratory waterfowl and are resident populations in many parts of the country during almost all months of the year. The Agency is concerned about the lethal exposure for these birds as well as for other kinds of non-migratory species such as songbirds. Bird kills on golf courses and other grass sites have occurred throughout the year. (See table II-2).

In conclusion, the Agency is concerned with hazard mitigation for all birds that frequent golf courses and sod farms. This is not limited to just migratory waterfowl, but includes other non-migratory birds. Both migratory and non-migratory water and songbirds have been killed on golf courses throughout the year. Limiting the use of diazinon to certain months will thus not mitigate the avian hazard.

3. Limiting Application Geographically

To reduce the hazard to birds, the Agency considered limiting diazinon application to golf courses and sod farms outside the areas that constitute the four major goose and duck migration flyways. Waterfowl such as Brant Geese migrate within specific corridors along the two coasts and by not allowing diazinon application in these areas the risk to these migrating birds could be reduced. The Agency believes that such a restriction could reduce the risk to birds in the flyways, but that birds in other areas would still be at risk.

The flyways are only generally defined geographically and in terms of broad corridors running north and south across the country (Bellrose, 1976). The birds not only fly within these corridors, but also move east and west. Kills on golf courses are documented throughout the country. Many of the migrating waterfowl that use the flyways may in any given year be found to fly over areas many miles outside of what is generally acknowledged as the heart of the flyway. Prevailing air currents, topographic features, and climatic conditions influence the general location of each flyway, but weather conditions and shifts in thermal patterns can dramatically alter the flight routes of the birds. Route changes can occur virtually overnight, between seasons, or over the years.

Limiting the use of diazinon to golf courses and sod farms outside the major flyways also does not protect birds that either migrate outside the flyways or birds that do not migrate and frequent golf courses and sod farms not in the flyways. The Agency has record of bird kills which show that waterfowl have been killed on golf courses and other grassy areas throughout the country. (See table II-2). Some of these kills are outside the flyways (Bellrose, 1976; Stone and Gradoni, 1985). Other birds such as seed-eating songbirds have been killed from diazinon on golf ocurses outside the flyways as well.

4. Reducing the Application Rate

The label rate for application of diazinon could conceivably be lowered to a rate that might reduce the hazard to birds. In assessing the risk of diazinon, the Agency estimated residue levels based on the application rates currently on the label, which were compared to laboratory measures of acute toxicity to see if they were exceeded.

The Agency estimated residue levels for 1 lb ai/A are as follows:

Residue Estimates	Short Grass (ppm)		Long Grass (ppm)	
After Application	Average	Maximum	Average	Maximum
-immediately following	125	240	92	110
-6 weeks later	5	30	5	20

When compared to the LC_{50} of 191 for Mallard Ducks and LC_{50} of 245 for Bobwhite Quail, it appears that the hazard is reduced except for the maximum residues resulting immediately following application. However, the Agency does not have data to determine if the risk to birds would be lowered to a level which would not be hazardous to birds. The risk could still be underestimated because a twofold to threefold difference in the average daily rate of food consumption may occur (Kenaga, 1973; Bellrose, 1976). Also, only a few granules equals or exceeds the LD_{50} for many smaller birds. Rate reduction would still not provide safety. As noted earlier, Agency records indicate lethal residues are regularly lower than laboratory toxicity values. Finally, the Agency does not have data indicating that diazinon would be efficacious at a lower application rate. This is of special concern because some diazinon labels direct the user to apply diazinon "as needed" to control certain turf pests. It is possible that the user may end up using as much diazinon at the lower rate because as many repeat applications may be needed.

F. Risk/Benefit Analysis of Regulatory Options

If the registrations of diazinon products which are used on golf courses and sod farms were continued without restriction (option 1), the Agency has determined that birds would be killed as a result of diazinon application and that this effect would be unreasonable in light of the benefits associated with diazinon use.

The Agency has evaluated amending the terms and conditions of registration (option 2) by modifying labeling to include additional precautionary language, limiting application to certain geographic areas or certain months of the year, or reducing the application rate. The Agency has determined either that these measures would not adequately reduce the risk to birds or that data are lacking to indicate whether they would adequately reduce risk.

If the registrations of diazinon products registered for golf courses and sod farms were cancelled (option 3), the risks to birds from diazinon exposure from these sites would be eliminated. Both the Agency hazard assessment and the number of bird kills which have occurred throughout the country demonstrate that diazinon poses a significant hazard to birds of all kinds, even when label directions are followed.

Cancellation would result in an increased cost per year of $937,200 for golf courses and $300,000 for sod farms. However, these impacts are considered to be minor relative to the total maintenance budgets and pesticide purchase costs.

Based on the significant hazard to birds and on the minor benefits, the Agency has determined that the risks outweigh the benefits and that use of diazinon on golf courses and sod farms must be cancelled to prevent unreasonable adverse effects.

G. Summary of Proposed Decision

The Agency proposes to cancel all products containing the active ingredient diazinon and that may be used on golf courses and sod farms.

The Agency is concerned about the protection of endangered species found on golf courses and sod farms. A formal consultation with the Office of Endangered Species has been requested.

The Agency is concerned about the hazard of diazinon use to birds on other sites. The Agency will be requiring data on these sites to fully evaluate the risk. After reviewing these data, the Agency will determine if additional regulatory action is necessary.

The Agency is also concerned about the avian toxicity of the alternatives. Agency estimates of the hazard and lack of bird kills indicates that the alternatives probably do not pose a greater hazard to birds than diazinon. However, the Agency will determine if regulatory action is appropriate as additional information is reviewed.

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